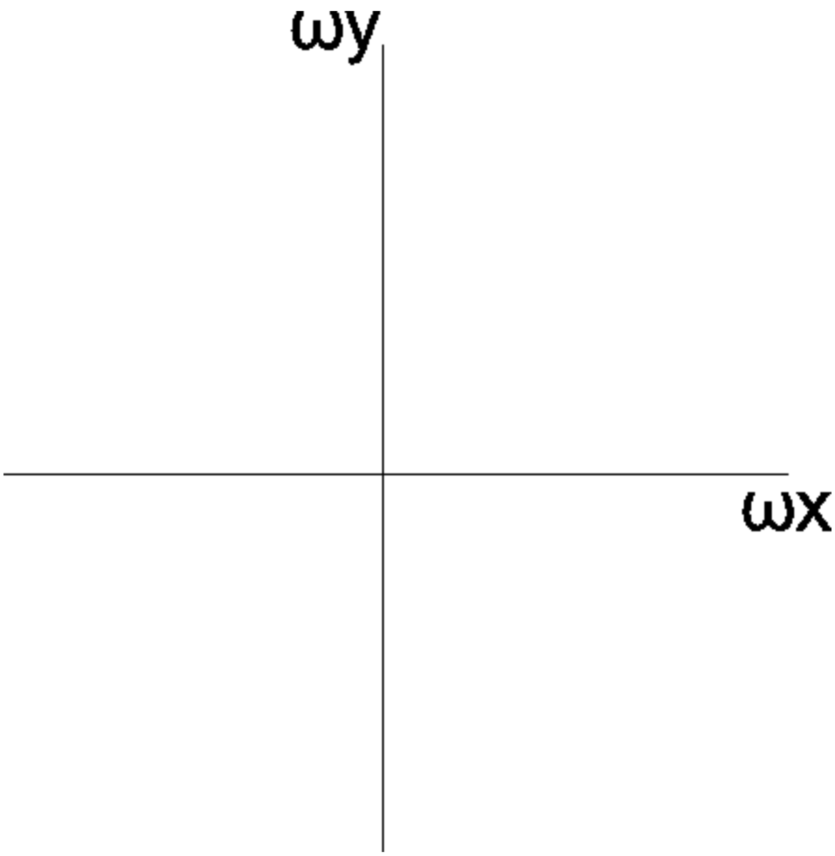
問題 1

The Fourier transform of the image whose density $g$ is defined by

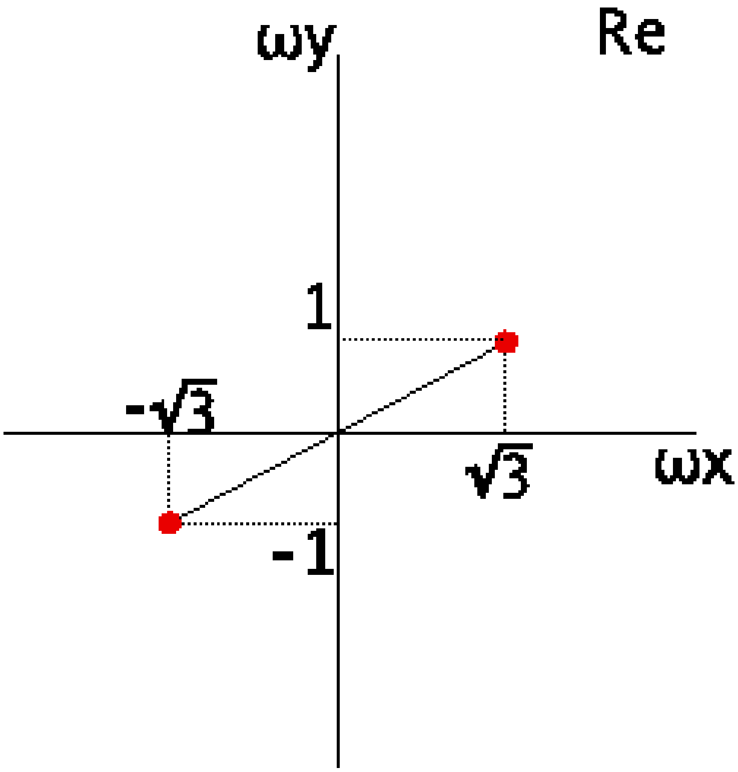
$$g(x, y) = \sin(ax + b\sin(cy))$$

, where a, b, and c are constants, gives a set of impulse functions. Derive the impulse functions, and illustrate them in frequency domain.



問題 2

In the following two graphs, a red point represents a delta function, and these graphs correspond to a sinusoid wave in image domain. Derive the sinusoid wave by 2 dimensional Inverse Fourier Transform.



問題 3

Illustrate this transformation on the next coordinate system graph, just like the illustration of the HSV color coordinate system in a handout of this lecture.

HSL の定義により，

$$L = \frac{1}{2}(\max + \min)$$

$$S = \begin{cases} 0 & \text{if} L = 0 \text{if} \max = \min \\ \frac{\max - \min}{\max + \min} & \text{if} 0 < L \leq \frac{1}{2} \\ \frac{\max - \min}{2 - \max - \min} & \text{if} L \geq \frac{1}{2} \end{cases}$$

$H$ は HSV の定義と同じく，色相の回旋角度を表す．$L$ は最大値と最小値の平均を取り，$L$ の値が $\frac{1}{2}$ 以上かどうかによって $S$ を決めるため，次は $L$ の値によって別々示す．

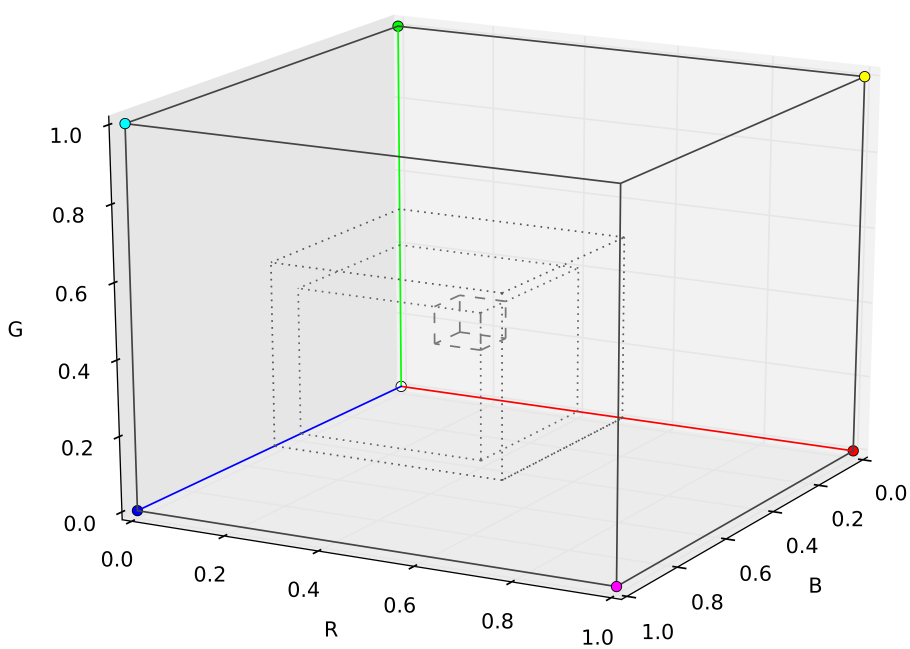



図 1　$L < \frac{1}{2}$

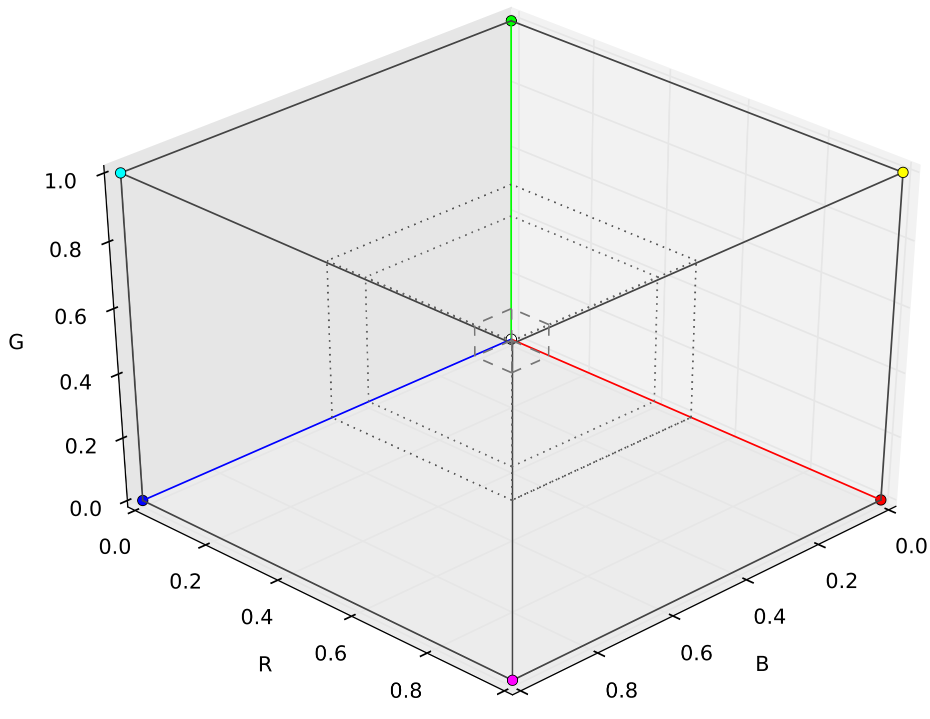



図 2　$L < \frac{1}{2}$

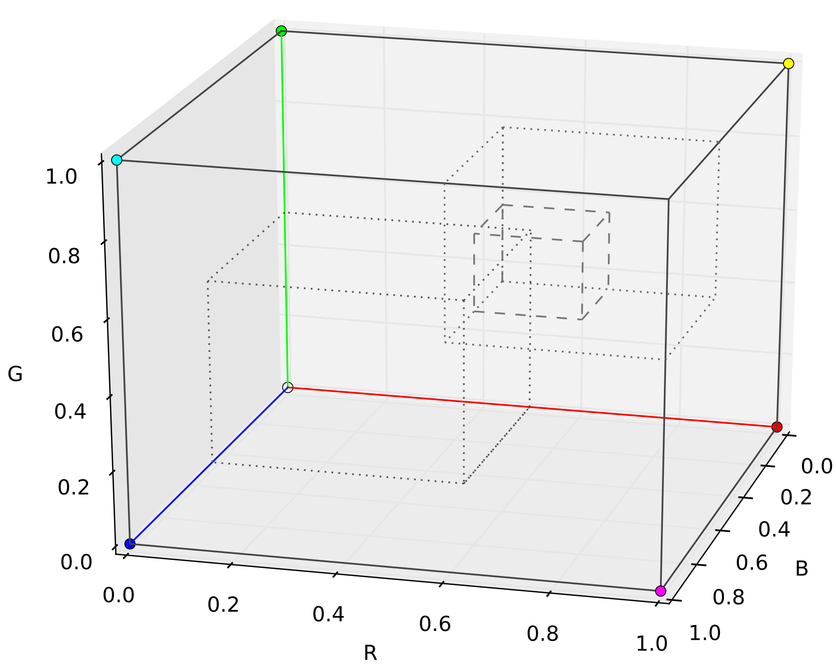



図 3　$L < \frac{1}{2}$

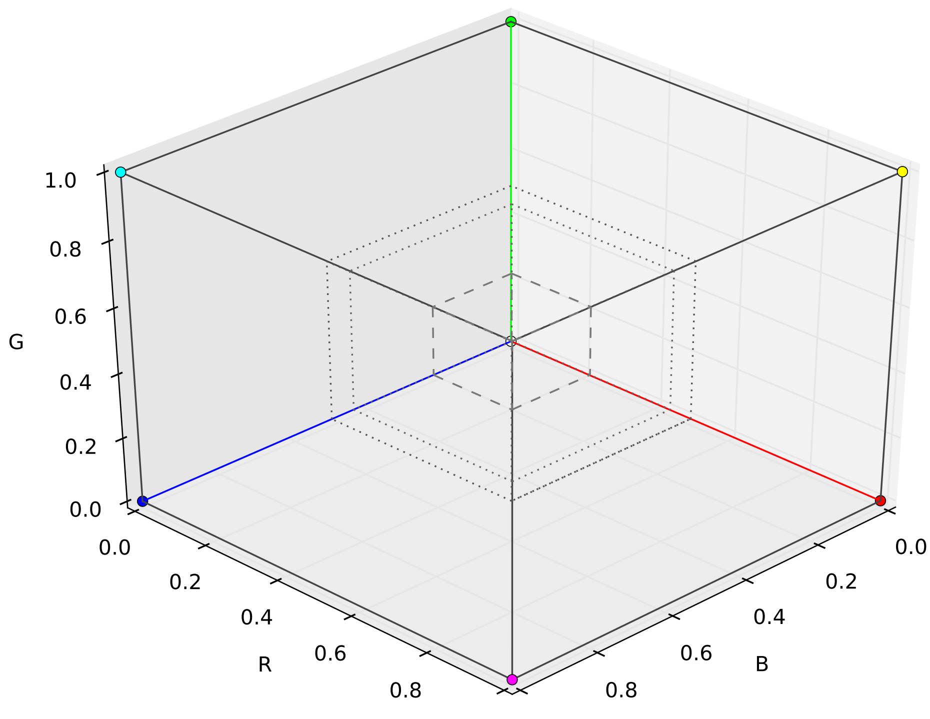



図 4　$L < \frac{1}{2}$

問題 4

1. Calculate the point for each pigment illuminated by a D65 light source on CIEXYZ 2degree. Here, assume that the values at less than 400nm are equal to the value at 400nm and the values at greater than 700nm are equal to the value at 700nm, and approximate the spectrum of the D65 light by black-body radiation at 6504K.
2. Plot them and draw a triangle of sRGB color space on the same xy color diagram.
3. Mark pigments which cannot be displayed correctly on sRGB monitors.
4. Think of a method to display such colors on sRGB monitors as natural as possible and explain it. The explanation has to mention problems by the method.

1. 次の **Color Matching Function** を用いて各 Pigment の **Reflect Function** に対応する XYZ 値を算出する.

$$\mathcal{X} = k\int_{400}^{700} D_{65}(\lambda)x(\lambda)r_{\mathrm{plot}}(\lambda)d\lambda$$
$$\mathcal{Y} = k\int_{400}^{700} D_{65}(\lambda)y(\lambda)r_{\mathrm{plot}}(\lambda)d\lambda$$
$$\mathcal{Z} = k\int_{400}^{700} D_{65}(\lambda)z(\lambda)r_{\mathrm{plot}}(\lambda)d\lambda$$

$$X = \frac{\mathcal{X}}{\mathcal{X}+\mathcal{Y}+\mathcal{Z}} \quad Y = \frac{\mathcal{Y}}{\mathcal{X}+\mathcal{Y}+\mathcal{Z}} \quad Z = \frac{\mathcal{Z}}{\mathcal{X}+\mathcal{Y}+\mathcal{Z}}$$

但し

- $\lambda$：波長
- $D_{65}(\lambda)$：光源データ
  `http://cvrl.ioo.ucl.ac.uk/database/data/cie/Illuminantd65.csv`
- $x(\lambda), y(\lambda), z(\lambda)$：**XYZ_CIE_2.dat** に測定されたデータ
- $r_{\mathrm{plot}}$：各 plot の **Pigments File** に定義された反射関数.

表 1　各 Plot に対応する XYZ 値

| Plot | $X$ | $Y$ | $Z$ |
|---|---|---|---|
| 1 | 0.556680 | 0.349468 | 0.093852 |
| 6 | 0.540825 | 0.326594 | 0.132581 |
| 15 | 0.500518 | 0.251735 | 0.247748 |
| 33 | 0.312706 | 0.329460 | 0.357834 |
| 41 | 0.321685 | 0.340942 | 0.337373 |
| 46 | 0.317175 | 0.334973 | 0.347852 |
| 51 | 0.172133 | 0.119266 | 0.708601 |
| 58 | 0.198234 | 0.197832 | 0.603933 |
| 64 | 0.294274 | 0.226222 | 0.479504 |
| 72 | 0.229489 | 0.404458 | 0.366053 |
| 74 | 0.261645 | 0.430408 | 0.307948 |
| 84 | 0.503193 | 0.450467 | 0.046340 |
| 92 | 0.456986 | 0.485291 | 0.057723 |

2. Wikipedia により，sRGB 色空間に於ける Red,Green,Bule と White はそれぞれ次である．

表 2　The sRGB gamut

| Chromaticity | Red | Green | Blue | White point |
|---|---|---|---|---|
| $X$ | 0.6400 | 0.3000 | 0.1500 | 0.3127 |
| $Y$ | 0.3300 | 0.6000 | 0.0600 | 0.3290 |
| $Z$ | 0.0300 | 0.1000 | 0.7900 | 0.3583 |

$XY$ 空間に描くと，次の三角形になる．「○」印の点は各 Pigments である．

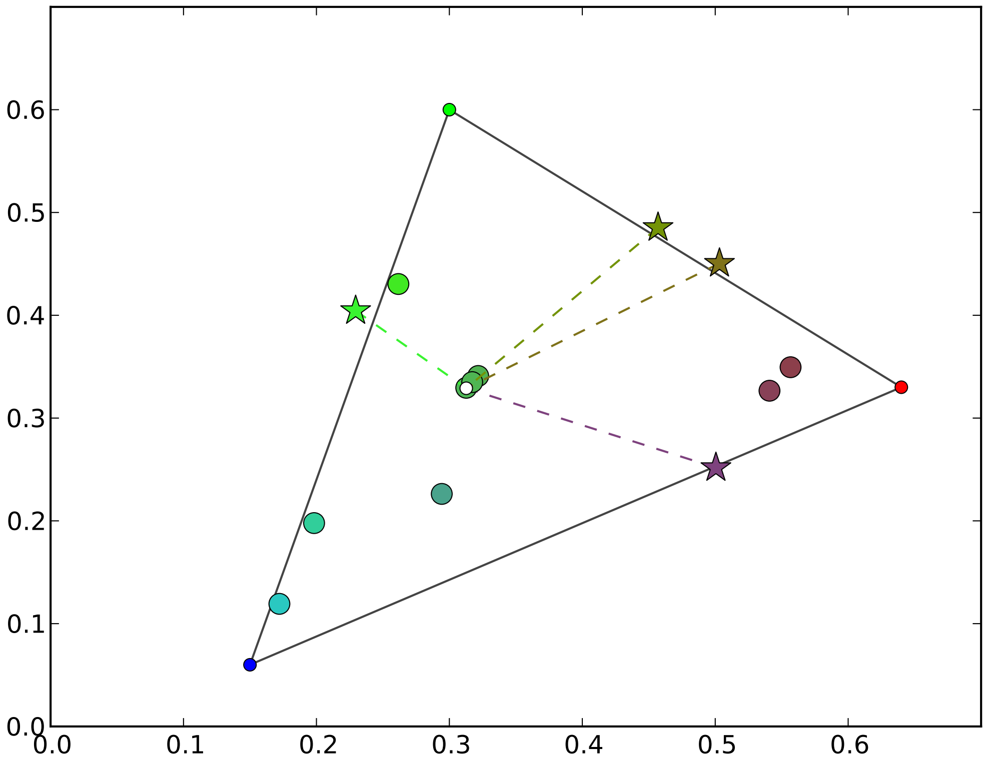



図 5　sRBG 色空間

3. 図 5 に於ける「★」印の点は sRGB 空間に入られない点である．
4. sRGB 空間で表示できない点を sRGB 空間の中の近い色の点を用いてシミュレートすれば良い．図 5 の破線のように，白点（White Point）から sRGB Gamut に含まれない点に線を引き，その線と sRGB Gamut の交点の色を使うと sRGB 以外の点も表示できる．